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Device and method for testing a safety valve

The invention relates to a device and to a method for testing a safety valve installed on a pressure tank.

German patent DE 35 08 685 C2 discloses a so-called full-lift safety valve that has a spring-loaded cone installed in the housing of the safety valve as well as a valve seat, whereby the spring presses the cone against the valve seat. The valve seat is arranged on the front end of a nozzle that is connected to the pressure tank. If the operating pressure inside the pressure tank exceeds a prescribed value that is defined by the springiness of the spring that pretensions the cone, then the cone is pressed away against the springiness and the spring-loaded cone is pushed back and executes a lift of limited height, a full lift. If the operating pressure inside the pressure tank falls once again below the prescribed value, the spring presses the cone back against the valve seat, thus closing the safety valve again.

The above-mentioned safety valve has to secure the pressure tank without it being possible for the valve to become blocked. In order to ensure safety, regular testing of the safety valve is needed. However, with several of the safety valves known from the state of the art, the testing can only be performed after the installation containing the pressure tank has been taken out of operation. The only exception to this is if at least two safety valves have been redundantly installed downstream from a special two-way valve. Then, in order to test the safety valves, the two-way valve is switched over so that each safety valve can be tested individually.

Gas-supply systems that are equipped with the above-mentioned safety valves are sometimes operated for prolonged periods of time. This often gives rise to problems during the regular testing of the safety valves. Not least of all, these problems have to do with the fact that maintenance personnel can only perform a safety test once the gas-supply system is has been taken out of operation.

German patent application DE 38 09 233 A1 as well as European patent application EP 0,007,769 A1 disclose devices in which safety valves can be tested during operation. In the subject matter of these publications, a force that acts in the opening direction of the valve is continuously increased. The opening pressure of the safety valve is determined on the basis of the force needed to open the valve. There prior-art devices, however, have the drawback that the safety function of the valve is not present while the safety valve is being tested.

Likewise known from the state of the art are safety valves in industrial installations such as, for example, power plants, steam generators or chemical production facilities for which testing devices exist. Such complex testing devices are known, for instance, from European application EP-A 0,028,661 or U.S. patent no. 4,949,288. With these testing devices, a spindle that functions together with a force sensing device is raised against the force of a spring that presses the valve cone against the valve seat of a safety valve. The spindle is usually moved hydraulically, for instance, by means of oil or air pressure. The forces, movements and operating pressures that occur in this process are detected simultaneously by electronic measuring devices so that a computer can then ascertain very precise values for the response pressure of the tested safety valves.

These devices, however, are too complex to test the function of small safety valves. Once again, these testing devices do not allow applications in which the safety function of the valve to be tested is maintained during the testing.

Therefore, the present invention is based on the technical objective of configuring and refining the device known from the state of the art in such a way that the safety function of the valve to be tested can be maintained while the safety valve is being tested.

According to the invention, the above-mentioned technical objective is achieved by a device for testing a safety valve that is installed on a pressure tank and that has the features of Claim 1. Connected to the cone, there is a tie rod that has a latching element and that prescribes a longitudinal direction. A counter flange is arranged at a prescribed distance

from the valve housing of the safety valve in the longitudinal direction. Furthermore, a force sensing device is provided that can be moved and fixed relative to the counter flange. According to the invention, a latching hook is connected to the force sensing device and said hook is detachably engaged with the latching element that is located on the tie rod. The detachable connection between the latching hook and the latching element of the tie rod is designed in such a way that the tie rod can be moved independently of the latching hook along the entire lift in the opening direction of the safety valve. Thus, on the one hand, the tie rod can be raised by the force sensing device and the latching hook in order to test the safety valve, so that the cone is raised from the valve seat. On the other hand, if the prescribed response pressure of the safety valve is exceeded, the cone can move independently of the latching hook in the opening or closing direction in order to relieve the excess pressure from the pressure tank. Consequently, the safety valve can be tested without having to take the pressure tank out of operation.

In a preferred manner, the latching element is designed as a depression, especially a circumferential groove, that has a contact surface for the latching hook at the end that faces the counter flange and a preferably conical, rising surface at the end that faces away from the counter flange. The latching hook can then be engaged with the contact surface in order to move the latching hook in the opening direction of the safety valve. If, in contrast, the pressure inside the pressure tank rises above the prescribed pressure, the cone is raised by this operating pressure, as a result of which the latching hook is separated from the contact surface and it is then disengaged from this surface, for instance, along the rising surface of the latching element, or else it is swiveled away by the tie rod with the use of spring force. In this manner, the cone can execute a full lift and allow gas to escape from the pressure tank. This then takes place independently of the testing device attached to the safety valve.

In another preferred manner, the latching hook is rotatably attached to the force sensing device by means of a hinge connection so that the latching hook can be swiveled so as to engage with the latching element, whereas the force sensing device, in contrast, only needs to be linearly moveable. In this context, in another preferred manner, there is a spring that

pretensions the latching hook away from or towards engagement with the latching element of the tie rod. If the spring presses the latching hook away before engaging with the latching element, then the latching hook is mechanically engaged with the contact surface of the latching element when the device is adjusted so that the latching hook is positioned in the lengthwise direction under tensile stress. Due to frictional forces, the latching element and the latching hook remain engaged with each other until the tensile stress subsides and the spring presses the latching hook away. This is particularly the case whenever an excess pressure opens the safety valve during the testing with the testing device and moves the cone with the tie rod in the direction of the counter flange.

If, in contrast, the spring pulls the latching hook towards the tie rod, the latching hook can automatically engage with the latching element. For this purpose, the end of the latching element facing the tie rod has a slanted sliding surface that, starting at the side that faces the tie rod, rises towards the outside, as seen from the direction of the force sensing device. Consequently, when the latching hook approaches the latching element, the sliding surface slides along the outer edge of the distal end of the tie rod, as a result of which the latching hook is moved towards the outside. If the latching hook is moved closer to the tie rod, the latching hook latches in the latching element under the tension of the spring, said latching element being in the form of a depression. If, in contrast, the latching element is designed as a flange projecting towards the outside, then the latching hook latches below the projecting flange.

In another preferred manner, in order to mechanically adjust the latching hook, there can be a lever connected to the latching hook, by means of which lever the latching hook can be moved against the spring force. As a consequence, when the testing device is put into place, the latching hook can be manually engaged with or disengaged from the latching element.

Additional features and advantages of the present invention will be explained on the basis of the detailed description of embodiments and making reference to the accompanying drawing. The drawing shows the following:

Figure 1 – a cross sectional view of a first embodiment of a device according to the invention;

Figure 2 – a cross sectional view of a second embodiment of a device according to the invention

Figure 3 – a cross sectional view of a third embodiment of a device according to the invention; and

Figure 4 – the embodiment shown in Figure 3, in a view along line IV-IV of Figure 3.

Figure 1 shows a first embodiment of a device according to the invention for testing a safety valve **2** installed on a pressure tank. The safety device **2** has a cone **4** and a valve seat **6**, whereby a spring **8** presses the cone **4** against the valve seat **6**. The valve seat **6** constitutes the front end of a nozzle **10** that is provided to let the gas enter the safety valve **2**. In Figure 1, the gas enters the nozzle from below until the gas pressure inside the nozzle, that is to say, inside the pressure tank (not shown here), is so high that the force exerted on the cone **4** by this gas pressure is sufficient to overcome the force of the spring **8**. Then the cone **4** is raised from the valve seat **6** and the gas flows into the gas outlet **12**.

In the open state, the so-called full-lift chamber is formed between the valve seat **6** and the bottom of the cone **4**. For this purpose, the end of the cone **4** that faces the valve seat **6** has a flange **14** which, in the raised state, comes to lies against the housing wall **16** of the valve housing **17**, thus prescribing the maximum lift, in other words, the full lift.

The spring **8** is arranged in a control pressure chamber **18** formed by the valve housing **17**. In order to allow a movement of the cone **4** relative to the valve housing **17**, there is also a guide **20** that is designed here in the form of a sliding bearing.

The control pressure chamber **18** and the gas outlet **12** are connected to each other by means of a pressure line not shown in Figure 1, so that shortly after the safety valve **2** has been opened, the control pressure chamber **18** is likewise charged with the high pressure which, together with the force of the spring **8**, causes the safety valve to close rapidly.

In order to test the function of the safety valve **2**, it is necessary to determine the response pressure and to compare it to the value prescribed for the special safety valve **2**. In this context, the objective of the invention is to carry out the testing without a need to dismantle the safety valve or to take it out of operation in any other way. This means that an unimpeded full lift with the corresponding blow-off performance can also take place while the safety valve is being tested. In order to accomplish this, the embodiment according to the invention exhibits the following features.

Connected to the cone **4** is a tie rod **22** that passes through an opening **24** arranged in the valve housing **17**. The passage through the opening **24** has a sliding bearing that allows a low-friction axial movement of the tie rod as well as a pressure build-up in the control pressure chamber **18**. Moreover, the tie rod **22** prescribes a longitudinal direction that runs vertically in Figure 1, along which direction the cone **4** and the axis of the nozzle **10** are aligned. The tie rod **22** has a latching element **26** that is arranged on the end of the tie rod **22** that faces away from the cone **4**. Furthermore, in the present embodiment, the latching element **26** has a depression **28** in the form of a circumferential groove.

As shown in Figure 1 as well, the device according to the invention has a counter flange **30** arranged in the longitudinal direction at a prescribed distance from the valve housing **17**. In the present embodiment, the counter flange **30** is configured as the upper wall of the housing **32** of the device for testing the safety valve **2**.

Furthermore, the device has a force sensing device **34** that can also be referred to as a force transducer. The sensing device **34** can be moved in the longitudinal direction relative to the counter flange **30** by means of a connected threaded rod **36** and a screw nut **38**, and it can be fixed at a prescribed position.

A latching hook **40** is pivotably connected to the force sensing device **34** and it has a projection **42** at its bottom in Figure 1. As shown in Figure 1, the projection **42** engages with the latching element **26** of the tie rod **22**. Therefore, by moving the screw nut **38** and thus

raising or lowering the force sensing device **34**, the position of the tie rod **22** can be changed.

As shown in Figure 1, at its end facing the counter flange **30**, the depression **28** has a contact surface **44** against which the projection **42** of the latching hook **40** lies during the engagement. Moreover, on its end facing away from the counter flange **30**, the depression **28** has a conically rising sliding surface **46**. As a result, while the latching hook **40** is engaging with the depression **28**, the tie rod **22** and thus the cone **4** can be raised in the direction of the counter flange **30** due to increased gas pressure in the nozzle **10**. Consequently, the lift of the cone **4** is made possible all the way to the prescribed full lift without this lift being hindered by the engagement of the latching hook **40** with the depression **28**. Therefore, the tie rod **22** can move by a full lift in the opening direction of the safety valve **2** independently of the latching hook **40**.

As already described above, the latching hook **40** is rotatably attached to the force sensing device **34** by means of a hinge connection **48**, whereby the axis of the hinge connection **48** is arranged essentially perpendicular with respect to the longitudinal direction. Likewise, a spring **50** is provided which, as a tension spring, pretensions the latching hook **40** in the direction of engagement with the latching element **26**. Thus, a permanent engagement of the latching hook **40** with the latching element **26** is ensured while the safety valve **2** is being tested. In order to establish and break the connection between the latching hook **40** and the latching element **26**, a lever (not shown in Figure 1) is provided with which the latching hook **40** can be swiveled against the force of the spring **50**.

As also shown in Figure 1, the end of the latching hook **40** facing the tie rod **22**, in other words, the projection **42**, has a sliding surface **52** that, starting at the side that faces the tie rod **22**, rises towards the outside, as seen from the direction of the force sensing device **34**. Therefore, when the force sensing device **34** is moved towards the tie rod **22** by actuating the screw nut **38**, the tie rod **22** is swiveled against the force of the spring **50** (tension spring) when the sliding surface **52** comes to lie against the facing end, until the projection

42 engages with the depression **28**, especially with the contact surface **44**, by a further adjustment of the force sensing device **34**. This allows an automatic engagement of the latching hook **40** when the force sensing device **34** and the latching hook **40** are put into place and adjusted.

In addition, the spring **50** can also be configured as a pressure spring that pushes the latching hook **40** to disengage it from the latching element. This pushing out during the engagement is prevented by friction forces which, however, are eliminated when the tie rod **22** is raised.

Figure 2 shows a second embodiment according to the invention that essentially corresponds to the embodiment shown in Figure 1. For this reason, Figure 2 only depicts a section of the safety valve with testing device shown in Figure 1. The difference from the first embodiment lies in the configuration of the tie rod **22** and of the latching element **26**. As shown in Figure 2, the latching element **26** is designed as a flange **54** having a contact surface **44**. The flange **54** has a diameter that is enlarged relative to the diameter of the tie rod **22**, whereby the tie rod **22** has an essentially unchanged diameter over its entire course all the way to the cone **4**. In this manner, the tie rod **22** can be raised in the nozzle **10** when excess pressure occurs, without its movement being hindered by the latching hook **40** that is pretensioned by the spring **50**, which is configured as a tension spring. The front tip of the projection **42** of the latching hook **40** then slides along the surface of the tie rod **22**, without hindering the movement of the tie rod **22**. After all, only the movement of the tie rod **22** towards the closed position of the safety valve **2** is limited by the latching hook **40** and by the latching element **26**.

The mode of operation of the two embodiments described above will be elaborated upon below. The testing device is placed onto the safety valve **2** whose closure cap (not shown here) has been removed. The latching hook **40** is engaged with the latching element **26** of the tie rod **22** and the screw nut **38** is tightened. This situation is shown in Figure 1. If the pulling force of the latching hook element **40** connected to the counter flange **30** via the

force sensing device **34** is further increased by tightening the screw nut, then the cone **4** rises from the valve seat **6** and the safety valve **2** starts to blow in an audible manner. In this condition, there is a state of equilibrium between the force of the spring **8**, the pulling force on the latching hook element **40**, measured by the force sensing device **34**, and the pressure-equivalent force under the cone **4**. If the pulling force of the latching hook element **40** is converted into the pressure unit bar via the safety-specific geometrical data, the sum of the operating pressure and the pressure ascertained by the force sensing device **34** corresponds to the response pressure of the safety valve when the cone **4** starts to open or is held aloft.

If the operating pressure, that is to say, the gas pressure inside the nozzle **10** rises while the safety valve **2** is being tested, and if this operating pressure approaches the response pressure, the pulling force on the latching hook element **40** drops accordingly. When the response pressure is reached, the tie rod **22** is detached from the latching hook **40** so that, as the response pressure is reached, the safety valve **2** can execute its full lift without being influenced by the device for testing the valve, thus preventing the pressure from rising impermissibly.

As already described above, the spring **50** can be designed as a tension spring or as a pressure spring. If the spring **50** is a pressure spring, then it pretensions the latching hook **40** against the direction of engagement with the tie rod **22** so that, when the tie rod **22** is detached from the latching hook **40**, the latching hook **40** is swiveled laterally and the tie rod **22** can subsequently move along the entire length of the full lift. This means that the safety valve **2** can operate entirely without being influenced by the testing device. If, in contrast, the spring **50** is designed as a tension spring, then the latching hook **40** remains in contact with the tie rod **22** so that the front end of the projection **42** slides along the surface of the tie rod **22**. If the spring **8** causes the cone **4** together with the tie rod **22** to be lowered once again when an excess pressure is being released, then the latching hook **40** once again engages with the latching element **26**.

Figures 3 and 4 show a third embodiment of the present invention in the form of a finished construction. In this context, the same reference numerals are employed to designate the corresponding components depicted in Figures 1 and 2.

The tie rod **22** traverses the interior of a connecting flange **56** that is attached to the valve housing (not shown in Figures 3 and 4). A knurled-head screw **58** serves to connect a mounting plate **60** with the top of the connecting flange **56**. Moreover, the disk-shaped counter flange **30** can be affixed at a prescribed distance from the mounting plate **60** by means of threaded rods **62**, spacers **64** and nuts **66**. A threaded nut **38**, which is in contact with the counter flange **30**, is operatively connected to a threaded rod **36**. A force sensing device **34** in the form of a force transducer is attached at the bottom of the threaded rod **36** so that the force sensing device **34** can be adjusted linearly relative to the counter flange. In order to prevent the force sensing device from rotating around the axis of the threaded rod, a pin **68** as well as an anti-rotation element **70** are connected to the threaded rod **36**. At the bottom of the force sensing device **34**, the latching hook **40** is rotatably connected around a hinge connection **48**, which is configured here as a pin. Moreover, the latching hook **40** is connected to a lever **71**. Furthermore, there is a spring guide **72** as well as a spring **50** which, in the same manner as described above, is configured as a tension spring or as a pressure spring. On the one hand, the latching hook **40** has a narrow segment **74** and a projection **42** at its bottom. The narrow segment **74** is dimensioned in such a way that the tie rod **22** can execute a relative movement along the narrow segment **74**. On the other hand, the projection **42** has a recess **76** that can engage with the depression **28** of the tie rod **22**. This is particularly visible in Figure 4.

The mode of operation of the device for testing the safety valve **2** of the third embodiment corresponds to the first two embodiments, as a result of which it will not be elaborated upon in detail here. It should only be mentioned that the lever can be used to swivel the latching hook **40** around the axis of the hinge connection **48** by lifting the lever so as engage the latching hook **40** with the depression **28** when the testing device the is put into place and adjusted. This allows a simple mounting as well as dismantling of the device.